Spatial Variation of Land Value and Land Use - Case Study of Sendai and Hirosaki

Spatial Variation of Land Value and Land Use
——Case Study of Sendai and Hirosaki*

Norio HASEGAWA

1. Introduction

In his previous report[1], the author made a general reference to the usual location theories in the study of agriculture and the areal structure theories in urban studies. In these theories it is considered that agricultural land use is arranged regularly around the city as a center on the one hand, while an urban area is differentiated to some concentric zones with different types of land use on the other hand. The two groups of location theories of land use deal with their own fields respectively on the basis of factors different each other. However, the concept of land use in urban and rural areas should be monistic, and the regular pattern of land use should be explained on the basis common to urban and rural.

Then, the author, in another report[2], readjusted the indicators of land use adopted in the usual studies, and classified them into two categories applicable to both rural and urban land use. One of them is the economic factor of land use such as intensity, net-income, land rent and land value, and the other is the type of land use which may be the phenomena as the projection of the former. The author also pointed out that the theories of intensity of agricultural land use can be generalized and applied to urban land use. That is to say, if the difference between price of products and production cost per unit area varies from a place to another, the intensity of land use may also differ from place to place, and the intensity allowed to a particular place ought to bring about a particular type of land use. In general, commerce, service, manufacturing and agriculture are arranged in order from high intensity to low one. The land use with high intensity bears high land rent. This is applicable to both cases, same type of land use with different intensity and different types of land use. If one wants to own and use a piece of land which can yield any land rent, there occurres the competition for the ownership. If a buyer and a seller expect the land to yield the stable income in future, the land has

* The report is a part of the doctoral dissertation on the title of "Geographical Study of Location of Land Use" presented to Tohoku University in 1961.

1) Norio Hasegawa: A Problem in the Geographical Study of Location of Land Use, The Liberal Arts Review, Tohoku University, No. 11, 1963.

2) Norio Hasegawa: A Study of Intensity of Land Use (in the press).

a certain value which is the price of land rent divided by general rate of interest. Therefore, the land rent and land value may vary in proportion to the intensity. On these premises, the author intends to discuss the geographical pattern of land use in this report.

2. Distribution of land value

For the purpose of showing the distribution of intensity of land use, land value is used as an indicator, which is admitted as rational in the previous report[3]. Land value is closely related with the intensity of land use and land rent, and the information of land value is more easily available than the data of the intensity of land use and land rent, to draw the distribution map of the intensity of land use.

The data of land value used in the report, is obtained from the information by Sendai Branch Office of the Bureau of National Tax, which involves the fundamental assessment value of private land in order to assess the tax in 1961. The method to assess land value is established in detail by the law[4], but it is omitted in the report. Sendai and Hirosaki are selected as examples. The land value as an assessment-value is neither the actual price of land by a sale, nor the value calculated based on the actual land rent. In the case of Sendai, the assessed land value is estimated so low as 26–27 percent of actual land value, and the rates of underestimation are uneven within the city of Sendai. In the urban area of Sendai the rate is estimated at 26–27 percent, while in the residential area in the suburbs there are many cases that it is estimated at one-fifth of the actual value. The uneven rates of estimated land value may be the result of not only the imperfect method of assessment, but also the influence of speculation upon the decision of the price, as stated later. However, as the land value assessed is set on a standard in a region, it may still be one of the best ways to use that figure for the analysis of the distribution of land value.

The distribution maps of land value were prepared in the following ways; the mesh was laid over the maps of Hirosaki and Sendai with their environs in the scales of 1: 10,000 and 1: 25,000 respectively. On the map of Hirosaki, the urban area is sectioned by cross mesh with intervals of 100 meters and outskirts of the city is sectioned with intervals of 250 meters; and on the map of Sendai the intervals are 125 meters and 250 meters respectively. Each crossing represents its environs, and the land value of each place is filled in there. Then, the figures of the places are connected with isopleths on the map. The distribution of land value is

3) Norio Hasegawa: ibid., 2).
4) cf. Financial Office of Sendai City: The Method of Assessment of Fixed Assets, 1961.

shown in Figs. 1 and 2.

In Hirosaki, the highest land value is found at the shopping street across the

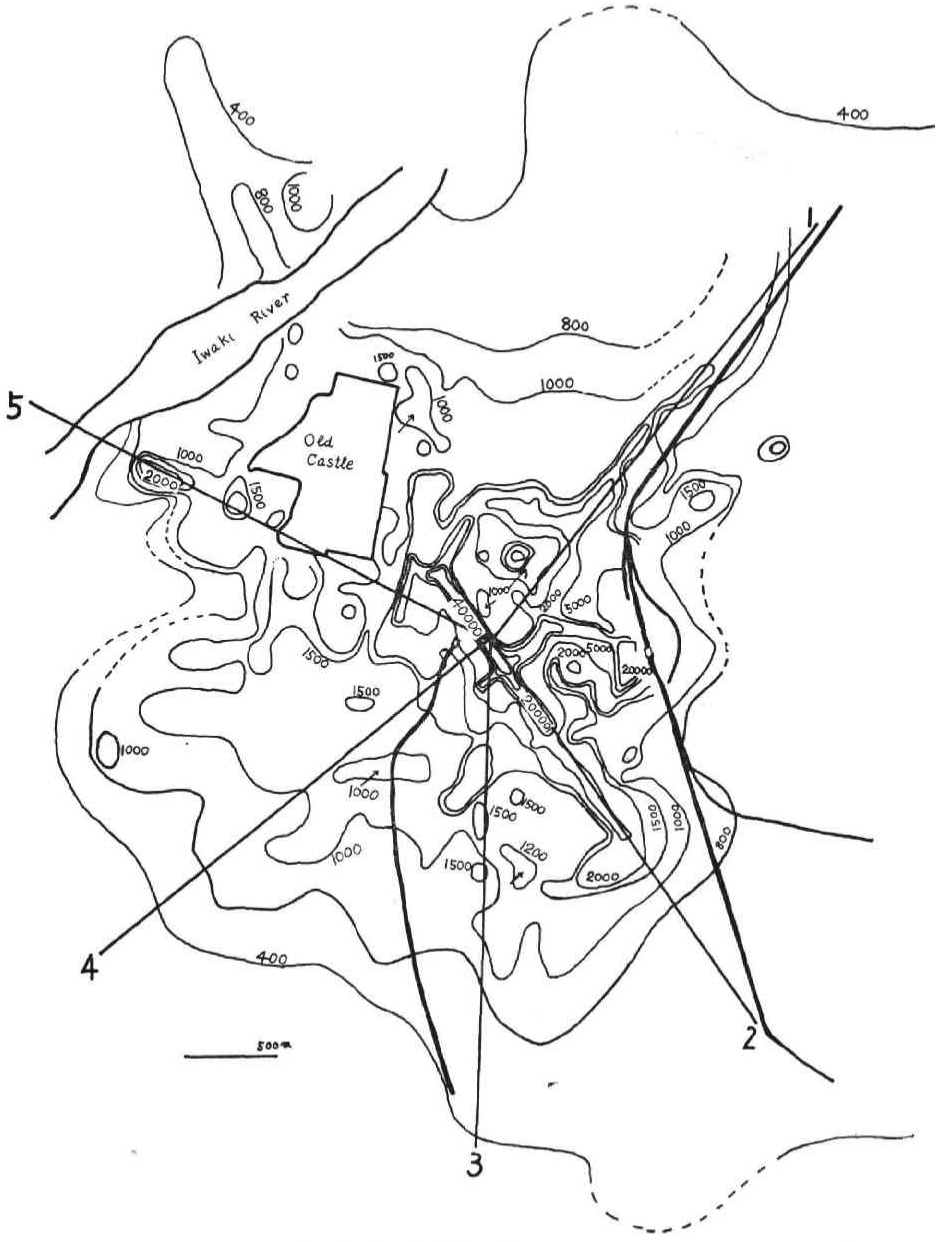

Fig. 1. Distribution of land value in Hirosaki city (*yen* per 3.3 square meters).

Fig. 2. Distribution of land value in Sendai city (*yen*).
(In Figs. 1 and 2, the lines with their numbers show the routes introduced in Fig. 5 and 6).

central part of the city from northwest to southeast, and the next highest land value is seen in the areas along the roads running from Hirosaki railroad station to the central commercial area and the areas along the roads derived from the shopping street. Around this H-shaped area with high land value, the land value goes down gradually from the central part to the suburbs, showing the relatively

high land value along the radial roads leading to the rural areas. The area to the north of the old castle which is now used as a park has relatively low land value, and it is relatively high in the southern residential area near the University, the northern part from the Hirosaki station and the northeastern part of the urban area.

Sendai has the higher land value in general showing a more complex distribution pattern than Hirosaki. The highest land value is distributed in the area in front of the Sendai railroad station, from which a shopping street with high land value runs to central part of the city forming T-shaped area, and from the center to the suburbs the land value drops gradually. At some parts in the urban area such as the northwestern part, Renbo, Ara-machi and Hirose-bashi, there are distributed the relatively high land values. The areas along the main roads running to rural areas have also relatively high land value with making a remarkable pattern of distribution, and the settlements located at rural areas such as Iwakiri, Tako and Arai are likely to be satellites with high land values. The northern part and the southwestern part of the urban area and the newly developed residential area of eastern and southeastern parts also have relatively high values. The dry-fields on the natural levees of the Natori and the Hirose Rivers near Sendai supply 90 percent of vegetables shipped to Sendai market, and there the land value varies fairly regularly in accordance with the distance from the urban area of Sendai. On the other hand, the land value of paddy rice fields does not change with distance. The expansion of urban area is restricted by hilly land-form in the northern and western parts of the city. Nevertheless, it seems that the land value has a general trend to decrease gradually from the central part to the outskirts.

Thus, the distribution of land value forms the concentric circular pattern and land value goes down from the central part of an urban area to the rural area, as seen in the cases of Sendai and Hirosaki. The pattern is, of course, not perfectly circular, because it is influenced by the roads, transportation facilities, land form, development process of the area and as such. However, these factors are negligible in consideration of general trend of the distribution, and the irregularity of the distribution of the land value at some particular places, if there is any, ought to be exmained concretely. As the high land value at a certain place means the intensive use of the land, the distribution of the intensity of land use also shows the circular pattern.

3. Distribution of the type of land use

The distribution of the type of land use is shown in the maps of Hirosaki and Sendai (Figs. 3 and 4).

Concerning the location of land use, the land use maps of two cities are interpreted as follows, refering to the study of land use of six cities by Hoover[5];

1) The economic activities dealing with bulky commodities like heavy industry and warehousing tend to locate at terminal district or switching district along the railroads.

2) Highly centripetal establishments such as specialized retail and service, wholesales, banks and other business are located at the central part, perhaps affording best access to the people of the city as a whole.

3) Light industry and wholesale dealing with less bulky commodities tend to be located near the commercial center or residential areas, and non-specialized commerce and service are located outside the central shopping center. Accordingly, this area is mixed with the establishments of light industry, non-specialized commerce and residence.

4) Toward the outskirts of the third area, residences are increased, and small non-specialized stores, barbar shops and the like, are distributed dispersely.

5) On the outskirts of the city, the residences are decreased gradually, and increased is agricultural land use which in its twin changes from intensive to extensive use by degrees.

Concerning the spatial pattern of these types of land use, more intensive use tends to locate at inner zone of urban area according to the order of the grade of the intensity of the type, and this is not so different from the consideration of the areal structure theory[6] of city which was discussed in the previous report.

4. Correspondence between the spatial arrangement of land value and the type of land use

In the previous chapters, it can be acknowledged that the distribution of land value is regular forming concentric zones and that the type of land use tends to change fairly regularly from a center to outskirts with more intensive use in the inner part of a city. One may recognize the two groups having a similar trend in their spatial changes.

There have been some studies of spatial variation of land value. For exmaples,

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5) E.M. Hoover: The Location of Economic Activity, 1948, pp. 131–139.

6) E.W. Burgess: The Growth of the City, in Park ed., The City, 1925, T.V. Smith and L.D. White: Chicago: An Experiment in Social Science Research, 1929.
H. Hoyt: The Structure of American Cities in the Post-war Era, Amer. Journ. Soci., Vol. 48, 1942, pp. 425–492.
C.H. Harris and E L. Ullman: The Nature of Cities, Ann. Amer. Acad. Poli. Soci. Scei., 242, 1945.

7) Ely and Wehrwein: Land Economics, 1940, pp. 136–138.

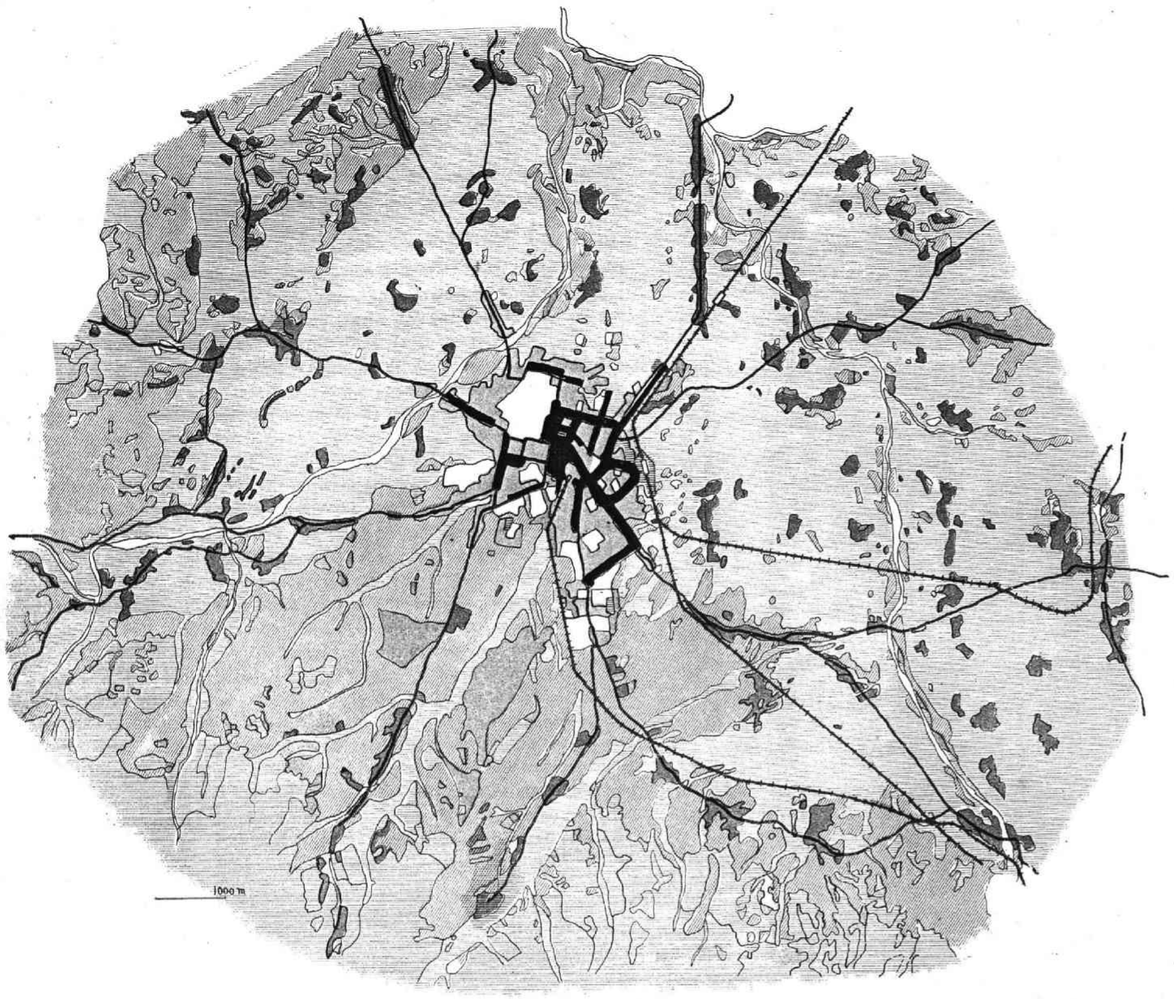

Fig. 3 Hirosaki City

Commercial and business district
Heavy industrial district
Light industrial district
Public establishment and open space
Transportation district
Residential district

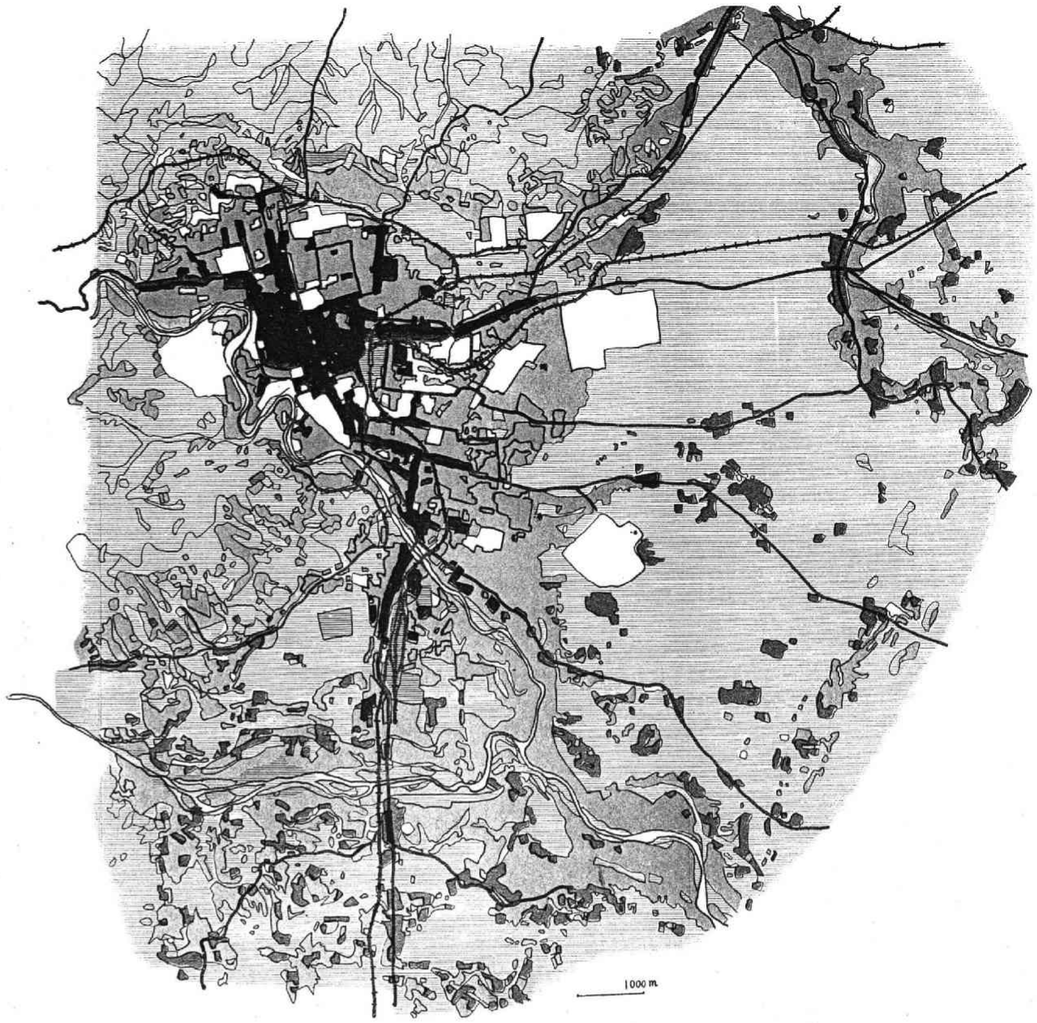

Fig. 4 Sendai City

Rural settlement
Paddy rice field
Upland field
Forest, grass land and Waste land
Apple field

the study of rural land use around Louisville by Ely and Wehrwein[7] and the study of farms around Stuttgart and Heilbornn by Lösch[8] who quoted the study by Hesse[9], show that the land value of farm land is decreased from the economic center twoard its outside areas. Concerning the land value of urban area, Lösch[10] and Hawley,[11] quoting Plopper's[12] study and Mckenzie's[13] study respectively, show that the land value is the highest in the central part of urban area and varies decreasingly toward suburban area. Chicago and Ann Arbar studied by Hoover[14] exemplify the regular variation of land value. These studies come to the similar effect to the author's study. However, the studies by Lösch and Hawley are not accompanied by a map showing the spatial change of the type of land use to compare with the distribution of land value. On the other hand, Hoover and Ely and Wehrwein discuss the spatial variation of the type of land use accompanied with the variation of land value, and the results of the studies are instructive with the same effect, in part, to the author's following work, though they treat with either urban land use or rural land use.

The change of the type of land use accompanied with the spatial variation of land value may be shown by two figures of Hirosaki and Sendai (Figs. 5 and 6). In the figures, the vertical absciss is the price of land value and the horizontal absciss shows the distance from the place with the highest land value. And along the horizontal absciss, the type of land use of each area is shown by symbols.

In the case of Hirosaki, the selected routes are the ways from the center toward northeast, southeast, south, southwest and western northwest; and in the case of Sendai, there are five lines from the center twoard northeast, east, southeast, west and northwest, and furthermore, two other lines are selected along the national road running to Shiogama and to Nagamachi and Fukushima. These selected lines are filled in the distribution maps of land value.

In the figures, highly specialized commerical and business uses occupy the places with the highest land value, and ordinary commercial and residential districts are arranged in the area of low land value. On each line, the arrangement is regular in general, though the places with the relatively high land value continue along the shopping street. However, from these figures one can not understand in detail the relation between land value and land use in rural areas. Fortunately,

8) August Lösch: Die Räumliche Ordnung der Wirtschaft, Translated from the Second Rev. Ed. by William H. Woglom: The Economics of Location, 1954, p. 354.
9) P. Hesse: Landvolk und Landwirtschaft in den Gemeinden von Württenberg-Hohenzollen, 1939.
10) August Lösch: ibid 8), p. 452–453.
11) Amos H. Hawley: Human Ecology, 1950, p. 266.
12) R. Klöpper: Niedersächsische Industriekleinstädte, 1941, p. 111.
13) R.D. Mckenzie: The Metropolitan Community, 1933, p. 234.
14) E.M. Hoover: ibid 5), pp: 138–140.

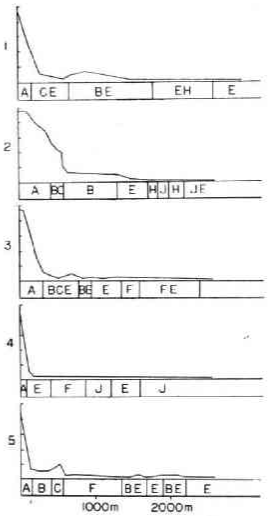

Fig. 5. Arrangement of land value (10,000 *yen*) and type of land use on the selected lines in Hirosaki city.

A Highly specialized commercial district
B Ordinary commercial district
C Business district
D Industrial district
E Residential district
F Public establishment district and open space
G Transportation district
H Paddy rice fields
I Upland fields
J Apple fields
K Forest land

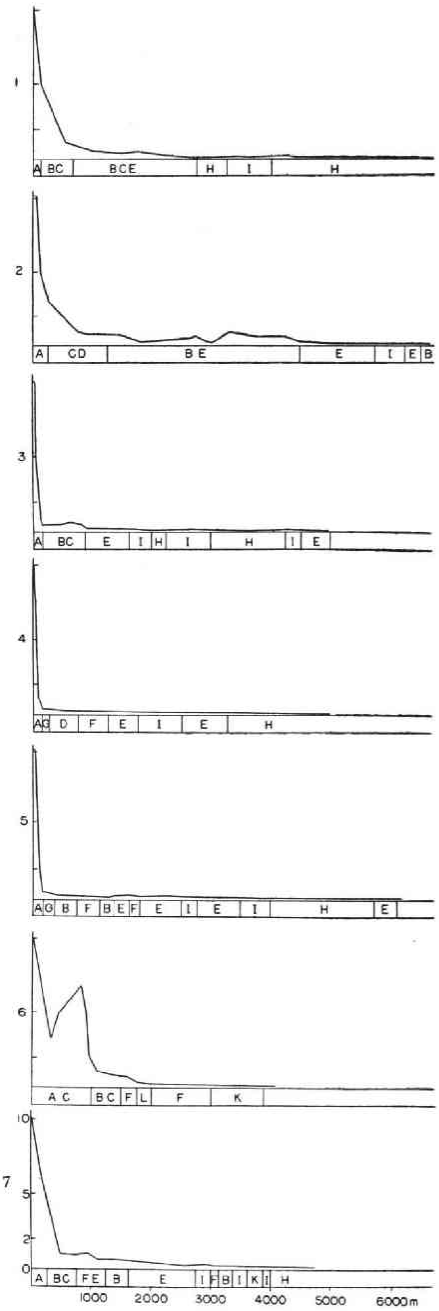

Fig. 6. Arrangement of land value (10,000 *yen*) and type of land use on the selected lines in Sendai city.
(Each line is shown in Figs. 1 and 2.)

the study of Louisville by Ely and Wehrwein[15] endorses the above view-point with important facts. And the author has analysed this point in his previous reports[16][17]. In the Iwaki basin the distribution of the intensity of apple culture according to the criteria such as mechanization, production cost and net-income, is comparatively regular around Hirosaki city as its center, with the change of the type of the culture accompanied. In the case of the outskirts of Sendai city, the ratio of non-agricultural households, the ratio of the income from the urban occupation by commuters living in a farm household, the average size of farm land managed by a farm household and the ratio of the products shipped to Sendai market are examined, and the suburb and rural districts are classified roughly into three types; the mixed area of residential and horticultural land use, the area of vegetable culture and the area of paddy rice farming. Deduced from these studies, it is clear that the rural land use varies with regular arrangement.

As was summarized in chapter 1, high intensity of land use yields high land rent, and theoretically, the price of the land rent divided by general rate of interest is land value. Accordingly, there is a close relation between land value and type of land use with the proper intensity. Theoretically, the higher the land value, the more intensive the type of land use, and vice versa. Consequently, it may be generalized that the spatial change of the type of land use accompanies with the spatial variation of land value.

5. Some consideration on the areal arrangement of the intensity of land use and the types of land use

The reason for the spatial arrangement of land value and of type of land use which vary regularly with distance from the center of a city is discussed here. Why the land use with high intensity tends to be located at the center of an urban area, and why the land use becomes extensive toward outer area of the city? In the procedure one should understand the arrangement of land use based on a common standard to both urban and rural.

The competition for the limited supply of land tends to allocate each site to a user and a type of land use capable of paying the highest rent per unit area, and

15) Ely and Wehrwein: ibid 7).

16) Norio Hasegawa: Areal Differentiation of Iwaki Apple Producing Region, Ann. Tohoku Geogr. Asso., Vol. 7, No. 2, 1954, pp. 55–62.
Norio Hasegawa: Qualitative Distribution of Apple Production in the Iwaki Basin, Ann. Tohoku Geogr. Asso., Vol. 7, No. 3, 1955, pp. 79–93.

17) Norio Hasegawa: Regional Geography of Miyagi Prefecture, Local Geography, 3, 1960.
Norio Hasegawa: Geography of Production of Miyagi Prefecture, History of Miyagi Prefecture, 5, 1960, pp. 131–224.

better sites will be bid up in rent and purchase price. Hoover[18] considers the processing cost and transfer cost as the decisive factors of land rent and land use type. Processing cost gives the pattern irregularity influenced by the elements such as the access to the water, nature of soils and climate, amenity of sites and costs of construction and maintenance on the one hand, and transfer cost may endow the spatial distribution of land use and type of land use with regularity on the other hand. It is the case first analysed more than a century ago by von Thünen[19] that a good site is one entailing low transfer costs. Since increased distribution costs reduce the net receipts of the producer, such producer can afford less rent, if they are farther from the market. Then, with increasing distance from market there is a rather consistent decline of ceiling rents payable by any one type of land use. Accompanied with the increase of saving of transfer cost the land rent becomes higher, and the type of land use with higher intensity may be located at the site. Thus, the circular zones of land use is formed as an outcome of the competition for good use of land, according to the difference of the land rent based on the difference of transfer cost of products and service.

However, there is a concept of accessibility which means the convenience of contact. Ely and Wehrwein[20] consider that the accessibility is a substitute for transportation; the accessibility has to be paid for in the rent or value of land, the transportation in time, inconvenience and cost of conveyance.

In these cases, the user of land should pay the land rent or land value instead of transfer cost corresponding to its saving owing to the accessible position of the site to their customers. However, in response to the demand of consumers for the products and service of land, as expressed in price, land uses become arranged in certain pattern, and land rent brought forth either by the saving of transfer costs or by accessibility acts as the arranger of this pattern. If the saving of transfer costs between any supply area and a demand area, or inversely between a supply area and any demand area, is the least in total, the case may be the most accessible in cost-distance, and this is the same as the case in which the number of supply area and demand area is either one or more respectively[21]. In the discussion of the competition of agricultural land use, it is only a special case in which extent supply areas and a city market are given in usual. In urban land use, sites depend largely on the advantage of close contact with site that affords to other producers and

18) E.M. Hoover: ibid 5), pp. 90–102.
19) Johann Heinrich von Thünen: Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie, 1826.
20) Ely and Wehrwein: ibid. 7), pp. 136–139.
21) cf. Norio Hasegawa: Spatial Association of Manufacturing in the Aizu Basin, Sci. Rep. Tohoku Univ., 7th Ser., No. 8, pp. 49–67.

consumers with whom the occupant may want to trade. The site occupies a position with the smallest transfer costs is the most accessible and it is allocated at the nodal point of transfer network. Therefore, accessibility is analogous to saving of transfer costs as a whole.

If one wants to measure the force of accessibility, the calculation of "population potential" by Stewart[22] may be much instructive. The grade of the connection between two areas may be shown in direct proportion to the size (measured by population or some indices of production and consumption volume) of the two areas and in inverse proportion to their mutual distance; the formula is often written "population of place 1 (p_1) times population of place 2 (p_2) divided by distance ($d_{1,2}$). If the formula is applied to the connection between an area and many other areas, and if the various demands are in proportion to the number of population, the concept of accessibility may be similar to that of the formula. If the number of population is equal in each unit area, or it decreases according to the distance from a center, the value of formula $\sum_{n=1}\left(\frac{p_1 p_{n+1}}{d_{1,n+1}}\right)$ is minimum in the case that the place (p_1) is situated at the center of the circle constituting whole area, and the place is the most accessible to the whole areas. Thus, as a result of the competition of alternative uses which sets the over-all pattern of land rents and land utilization, land use is arranged from a center to outer zones in a certain order according to the grade of intensity and land value (Fig. 7).

Residential use of land is necessary to be explained with additional view-point. Residential lot is not a productive element but a kind of consumer's goods. Economic activity is not operated at the residential lot, and it can not compete with another use for productive activity. Accordingly, the residential use is turned out of inner part of an urban area by other uses. But it must be accessible to the workshops and various functions in urban area in a certain degree, to be served by them, without much transportation cost and time. The location of residential use is decided by the ability to pay the land rent, but if the loss of transfer cost and time is more than the saving of land rent, residential use may shift to the next place with higher rent but with higher accessibility. The land rent of residential lot is also decreased according to the increase of time- and cost-distance. However, the location of residential use is influenced by additional factor: the amenity of neighbourhood.

Residential districts contain the areas with relatively high or low land value within their areas. In Hirosaki city, the land value is relatively low in the northern

22) J.Q. Stewart: Empirical Mathematical Rules Concerning the Distribution and Equilibrium of Population, Geogr. Rev., Vol. 37, 1947, pp. 461–485.

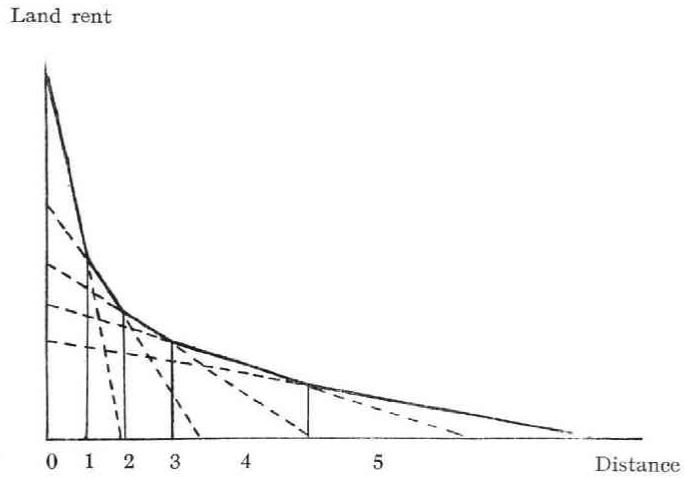

Fig. 7. Land rent gradients from urban center to rural area. The diagram shows the relation between distance from a center and rent in five different types of land use 1, 2, 3, 4, and 5. They arrange typically in the order of commerce, manufacturing, residence, intensive agriculture and extensive agriculture. Each of the five rent gradients is drawn as a solid line over the interval in which the corresponding land use is the highest rent use.

and western parts from the park under the terrace scarp and the streamside area across the urban area from south to north. The southern residential districts near Hirosaki University and the southern and eastern parts from the park have relatively high land value. In the residential districts of Sendai city, northern part of the central district and the the hilly land with gentle slope faced to south from northwestern to northeastern part have relatively high land value. And residential districts converted from the paddy rice field such as the southwestern and northern parts have relatively low land value. The eastern part from the Sendai station with damp ground has remarkably low land value, though it neighbours the district with the highest value. These irregularity in the distribution of land value in residential districts can not be explained by accessibility, and the physical environment of residence should be brought into consideration. The residential environments such as quiet place, clear atmosphere and sunny slope faced to the south are the favorable factors for the higher value, and places with complicated transportation access, places near noisy factories and badly drained places are detested. These environmental factors influence the land value in the residential areas. It should be said that the irregularity of the spatial variation of land value in residential areas is caused by the amenity value positive or negative added to the value based on the accessibility. Thus, concerning the explanation of the

distribution of land value in residential areas, the author does not differ from Hoover[23] and Ely[24].

Another irregularity is caused by relatively high land value often observed at the outer parts of urban areas. In Sendai, the area from the northeastern to south eastern part of urban area belongs to the areas which causes an irregularity.

The area corresponds to newly expanded urban fringe, its functional structure is not yet completed, and the possibility of conversion of land use in future is large. For examples, at Odawara-Nigatake district, the eastern part of the urban area of Sendai, the conversion of land use from agriculture to urban use has become noticeable with the last decade, since the district situates along the primary national road and national railways leading to Shiogama and Aomori, and it is well equipped with good transportation facilities. Here in the range of 10 kilometers along the national road, paddy fields and upland fields are almost converted to the use such as retail shops, repairshops of automobile, track-terminals, small food processing factories and other workshops. Nowadays, industrialization is remarkably progressing, and new development of factories, residences and shops is fully expected in the future. At the southeastern residential district, the assessed value is approximately 5–10 percent of actual value, as compared with estimate of 26–27 percent in the central part of the urban area. In 1952, the value per 3.3 square meters was 1,000 yen at Miyaginohara, and it increased to 4,500–5,000 yen in 1956–1957. And at Nimaibashi it was 3,000 yen in the same year. In 1958, a part of the land at Miyaginohara was sold with price of 7,000 yen for the purpose of establishing national freight-station, correspondingly, the land value at other places of Miyaginohara rose to 7,000 yen or more, and it rose also to 5,000 yen at Nimaibashi. As seen in the above exmaples, in the rapidly developing urban area, the type of land use has the potentiality for its change, and land value rises higher with it. In these cases, if the seller and the buyer anticipate the increase of income from land in the future according to their seculative thoughts, the land value is not decided on the basis of land rent from the actual land use alone, but may be decided on the basis of the prospected income from future land use. Then, the actual land value is the value calculated on productive basis added to the part based on expectation of an increase in the anticipated value of urban land. Such phenomena are also seen in the suburban areas used for agriculture and vacant land in urban areas in rapidly expanding cities in general.

Thus, in the case of the land with high value due to anticipated value, the rise of land rent in the future is prospected, and more intensive use of newly

23) E.M. Hoover: ibid 5), pp. 128–141.
24) Ely and Wehrwein: ibid 7), pp. 120–121.

urbanized area is expected. That is to say, the increase of intensity and the change of the type of land use such as the conversion of farm land and forest land to residential lots and factory land and the conversion of residential to commerical land, are the premise to the increase of the land value, and it should be characteristic in the urban area with much possibility to functional re-construction. It may be closely related to the increase of accessibility of the land.